COMPONENTS OF RESISTANCE TO LATE LEAFSPOT OF PEANUT AND STUDIES ON HEALTHY LEAF AREA DURATION

By

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COMPONENTS OF RESISTANCE TO LATE LEAFSPOT OF PEANUT AND STUDIES ON HEALTHY LEAF AREA DURATION

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Late leafspot, caused by Cercosporidium personatum (Berk. and Curt.) Deighton, is one of the most economically significant diseases of peanut (Arachis hypogaea L.) in Florida. The pathogen frequently causes severe defoliation and reduction in pod yield. The objectives of this research were i) to determine the relationship between components of partial resistance to late leafspot and disease progression, and ii) to examine the relationships of disease severity, canopy reflectance, healthy leaf area duration (HAD), and pod yield. Components of partial resistance to late leafspot were quantified and late leafspot disease progression were monitored on 14 peanut genotypes in field experiments at Marianna, Florida, during 1988 and 1989. Inoculated target leaves were used to determine various components such as, incubation period, latent period, maximum percentage of lesions that sporulated (MPLS), lesion size, lesion number, degree of sporulation, and percent necrotic leaf area. Genotypes included a resistant breeding line, (UF 81206), a moderately resistant cultivar, (Southern Runner), susceptible cultivar, (Florunner), and eleven breeding lines with various levels of resistance. Lowest AUDPC (area under the disease progress curve), rate of disease progress, and final level of disease were observed on genotypes UF81206, PI 261893, US 29-b3-B, and US 202-b2. Rate of disease progress and AUDPC were more highly correlated with MPLS and latent period than with lesion size, degree of sporulation, and percent necrotic area. MPLS and latent period were the resistance components that contributed most towards the reduction of disease progress in the field. Field studies on healthy leaf area duration (HAD) were conducted in 1988 and 1989 for peanut cultivars Florunner and Southern Runner. Spray treatments of chlorothalonil were applied to establish different levels of disease. Leaf area index (LAI) was measured eight times during the season and disease progression and percent reflectance were monitored. Healthy leaf area duration and green leaf area were calculated from LAI and the total amount of disease. Linear relationships were obtained between green leaf area index and percent reflectance at 800 nm for both cultivars. Pod yields for all treatments increased with HAD. Results support the concept that HAD can be used to predict yield and yield loss due to late leafspot disease.

CHAPTER 1
INTRODUCTION

The two major foliar diseases of peanut (Arachis hypogaea L.) are early and late leafspot caused by Cercospora arachidicola Hori and Cercosporidium personatum (Berk. & Curt.) Deighton, respectively (48). These pathogens have a worldwide distribution and occur wherever peanut are grown. Their prevalence differs from region to region. In Florida, late leafspot predominates over early leafspot, possibly since late leafspot-susceptible cultivars occupy a large percentage of the acreage planted to peanut. The primary strategy for leafspot control in the United States has been with fungicide application. Production of peanuts in Florida and other Southeastern states has mainly been based on the use of Florunner treated with chlorothalonil although at least seven other cultivars are now grown in this region. Other means of disease control are also being used in combination with host resistance and forecasting programs. This combination of tactics aims to minimize fungicide input and farmer's cost. Subsequently, the amount of pesticides in the environment may be reduced.

The "Equivalence Theorem" as theorized by VanderPlank (53) is of prime importance to management strategies for disease control and has been applied in certain pathosystems (13). The theorem states that changes towards a more resistant host, a less virulent pathogen, and a less favorable environment are equivalent in their effect on the epidemic process. Waggoner et al. (55) applied the "Law of Minimum" to study the relationship between pathogen, weather, and disease and to estimate the effectiveness of each of these factors on development of epidemics. Significant changes in the outcome of a disease depend on the most deficient factor. Small additions to the factors which are already abundant will have less effect on disease development. Information regarding the effect of each factor can be obtained from experimental observations and enables one to predict the future outcome of disease. Thus, an optimum combination of tactics can be formulated to obtain the most desirable program for disease management, one that incorporates chemical application, a weather forecasting system, and resistant cultivars.

Partial Resistance to Late Leafspot

Host resistance to disease can be described by such terms as "vertical" or "horizontal" (53). Vertical or complete resistance to late leafspot has not been found in cultivated species of peanut (Arachis) (1, 12, 14). However, horizontal or partial resistance is readily available (1, 3, 8, 9, 10, 16, 26, 33, 58). Several breeding lines have shown various degrees of partial resistance to late leafspot. This type of resistance has its major effect on the rate of epidemic development and Watson (58) described it as "slow-leafspotting". The rate of disease progress is determined by several factors or components which act together in influencing the epidemic process. Parlevliet (32) discussed the various components of host resistance affecting epidemic rate and final disease levels. These quantitative components include; infection efficiency (lesions per unit inoculum), the length of latent period, lesion size, length of the infectious period, and the amount of sporulation. Various components of resistance to both early and late leafspot have been identified (8, 12, 15, 26, 29, 30, 50, 51, 56, 58). Peanut lines with high levels of partial resistance to late leafspot exhibited long latent periods, small lesions, reduced necrotic area, and low amount of sporulation. Watson (58) evaluated three peanut genotypes for components of resistance. He reported that the cultivar Southern Runner and breeding line UF 81206 expressed resistance through reduced lesion size, reduced sporulation, and lengthened latent period. In addition, UF 81206, the most resistant genotype, never exceeded a maximum of 10% of the lesions with sporulation. In a series of tests, Chiteka (8, 9, 10) evaluated 116 peanut genotypes for components of resistance to late leafspot. The greatest variability among those genotypes was observed for lesion size and latent period.

There is a need to understand the interplay of each component and the relative contribution of each component in reducing the epidemic rate. Certain components may be more effective than others. Theoretical studies and computer simulations have been used to determine the relative importance of resistance components (23, 27, 59). Shaner and Hess (42) developed equations to predict how various components of slow-rusting resistance interact under field conditions. They showed how certain combinations of slow-rusting resistance components might retard the epidemic process. Jeger (22) used a multivariate technique to analyze the components of resistance to Septoria nodorum on wheat. With factor analysis, dominant contributing component factors were identified. Savary et al. (40) used simulations of peanut rust to show various hierarchical effects of individual components of resistance. They found that lengthening of the latent period had strong effects, sporulation and infection efficiency had moderate effects, while length of infectious period showed negligible effects. The maximum percentage of lesions of early leafspot that sporulated was the resistance component most highly correlated with disease progress in the field (24).

Disease-induced Yield Loss and Healthy Leaf Area Duration

In studying disease-induced crop yield loss, the simple idea of relating yield to the amount of healthy leaf area remaining in the plant canopy may be more useful than that of relating yield to disease severity. Several authors have dealt with the relationship between crop yield and disease severity or intensity. Findings are usually expressed in terms of equations developed through linear or multiple regression analysis. Various approaches to the study of disease and crop yield are critical point, multiple-point, and AUDPC models as reviewed by James (21). As Waggoner and Berger (54) pointed out, most of these correlations are disappointing and suffer from faults in logic such as failure of critical point and AUDPC to distinguish early and destructive from late and relatively harmless epidemics. Also, disease intensity-yield loss models which are based on crop growth are superior to models derived from signs and symptoms of disease (39). Waggoner and Berger (54) proposed instead the concept of relating yield to healthy leaf area duration (HAD) which is the integral of healthy leaf area during the season, and to a related variable, healthy leaf area absorption (HAA). They successfully demonstrated the concept for crops such as peanut, potatoes, corn, and wheat. They used data from previous studies and showed that the simple concept of HAD and HAA can be used to predict yield of manually-defoliated and leafspot-defoliated peanuts. Recently, Bourgeois (7) tested the concept of HAD and HAA to predict pod yield in peanut cultivar Florunner. He found the concept acceptable only for peanuts treated with fungicides.

However, for untreated and leafspot-defoliated peanut canopies, the concepts were invalidated. Bourgeois proposed that the equations developed to predict HAD and HAA were based on artificial or manual defoliation which could be different from leafspot-induced defoliation and that pod losses after complete defoliation were not considered. Potential yield should have been used in the computations of predicted pod yield instead of the harvested yield since time of harvest (in relation to crop maturity) had a pronounced effect on harvestable yield. Measurements of healthy leaf area have been used for studies of crop loss in other pathosystems such as potato blight (37, 38), take-all of winter wheat (19), and combination of early blight, Verticillium wilt and leafhopper damage in potato (25).

The objectives of this research were 1) to determine effects of components of resistance on disease progress (area under the disease progress curves and apparent infection rate), 2) to determine the relative contribution of components on reduction of disease in the field and identify the component(s) most limiting to epidemic development, and 3) to examine the relationships among disease severity, canopy reflectance, healthy leaf area duration, and pod yield.

CHAPTER 2
EFFECT OF COMPONENTS OF RESISTANCE ON PROGRESS OF LATE LEAFSPOT

Introduction

Cercosporidium personatum (Berk. & Curt.) Deighton, causes late leafspot of peanut which is one of the most economically significant diseases of peanut in the Southeastern US. Losses in yield attributed to this disease ranged from 10 to 50% (18). Complete resistance to this disease has not been found in cultivated species of Arachis; however, rate-reducing resistance is available (1, 3, 8, 9, 10, 12, 16, 26, 33, 58). Southern Runner, a new peanut cultivar with polygenic resistance, has recently been released by the University of Florida (17), and other advanced breeding lines with levels of polygenic resistance are being developed (16, 18). The primary strategy for control of leafspot has been the use of five to ten applications of a protectant fungicide. An integrated system of disease control has a potential to reduce production costs. An efficient system will probably utilize resistant cultivars, fungicides, and disease forecasts.

The research reported herein is part of a larger program on integration and optimization of tactics to control late leafspot. The goal of this program is to quantify the individual effects of resistance, fungicide, and disease forecasting on disease development. These combined tactics can then be used to minimize disease losses due to _C. personatum_. Prior to the present study, components of partial resistance for several peanut genotypes including commercial cultivars, germplasms, and advanced breeding lines were quantified under greenhouse and field environments (8, 9, 10). Genotypes for this study were selected based on this earlier work.

The overall objective of this research is to determine the effects of different components of host resistance, such as incubation period, latent period, lesion size, percent necrotic leaf area, and sporulation capacity, on the progress of late leafspot disease of peanut. Specific objectives are as follows:

1. To quantify the components of resistance for the selected genotypes.
2. To determine the overall effect of these components on the apparent infection rate and area under the disease progress curves (AUDPC).
3. To determine the relative contribution of each component on the reduction of the apparent infection rate.
4. To identify the component(s) that limit epidemic development.

Materials and Methods

Peanut Genotypes

Experimental materials consisted of 14 peanut genotypes as shown in Table 2-1. Twelve genotypes including the commercial cultivars Florunner and Southern Runner were selected based on previous analysis of resistance components (8). Selection of the genotypes was based on the relative rankings and values for latent period, incubation period, lesion size, sporulation score, and percent necrotic area (Table 2-2). Two additional genotypes, 79x4-6-2-1-1-b3-B and 79x4-6-2-1-3-b3-B, were also included based on their performance in other tests at the Agricultural Research Center in Marianna, Florida.

Table 2-1. Peanut genotypes evaluated for components of resistance in 1988 and 1989.

No.	Genotype
1	UF81206-1
2	72x32B-3-2-2-2-2-1-b3-B
3	72x83B-7-1-1-B
4	US29-b3-B
5	76x5-3-2-3-1-1-1-b3-B
6	76x9-10-1-1-1-2-b2-B
7	76x5-3-2-1-1-1-1-b3-B
8	PI 261893
9	79x6B-10-2-1-2-b3-B
10	US 202-b2
11	79x4-6-2-1-1-b3-B
12	79x4-6-2-1-3-b3-B
13	Southern Runner
14	Florunner

Table 2-2. Comparison of 12 selected genotypes based on various components of resistance[a] (data from Chiteka, 1987.

Genotype	IP	LP	SS	LS	PAS	PNA
UF81206	2	1	1	1	1	1
2	1	1	1	1	2	1
3	1	2	2	1	2	1
4	1	1	1	1	1	1
5	1	2	1	1	1	1
6	3	1	1	1	2	3
7	3	1	1	1	1	1
8	2	1	1	1	2	1
9	1	2	2	1	2	1
10	1	1	1	1	1	1
SR	3	2	2	1	1	2
FR	1	2	3	3	3	3
1	> 9.0	> 22	1-2	< 3.2	< 4.0	< 4.0
2	8.6-9	16-22	2-4	3.2-4	4-7	4-5.5
3	< 8.6	< 16	4-5	> 4	> 7	> 5.5
	(days)	(days)	(1-5 score)	(mm)	(1-10 score)	(%)

---

[a] Values for components of resistance are represented by a scale (1-3) as shown above (IP = incubation period, LP = latent period, SS = sporulation score, LS = lesion size, PAS = plant appearance score, PNA = percent necrotic leaf area, SR = Southern Runner, FR = Florunner).

Field Experiments

Field experiments were conducted at the Dozier Boy's School, Marianna, Florida in 1988 and 1989. Peanuts had not been grown on this site in the past 20 years. In both experiments, a randomized complete block design was used with four replications. In 1988, each plot consisted of two 6.1 m long rows spaced 0.91 m apart. During 1989, four-row plots were utilized. For both years, two rows of UF 81206, (a genotype with high levels of partial resistance to late leafspot) were planted between each plot. Selected peanut genotypes were planted on 28 May 1988 and 19 May 1989 at a rate of 30 seed/6.1 m and were inoculated with *Bradyrhizobium* in the furrows at planting. The fields were not irrigated. Figure 2-1 shows the amount of rain accumulated during the 1988 and 1989 cropping season. Standard cultural practices were followed with the exception that no fungicide was applied.

Components of Partial Resistance

One month after planting, three plants from each plot were selected and marked with flags. In 1989, six plants were selected in each plot. From each selected plant, three fully expanded tetrafoliate leaves were tagged. Inoculum was obtained from plants with late leafspot and was maintained in the greenhouse on 1- to 2- month-old peanut plants (cvs. Early Bunch and NC 3033). Conidia were collected from sporulating

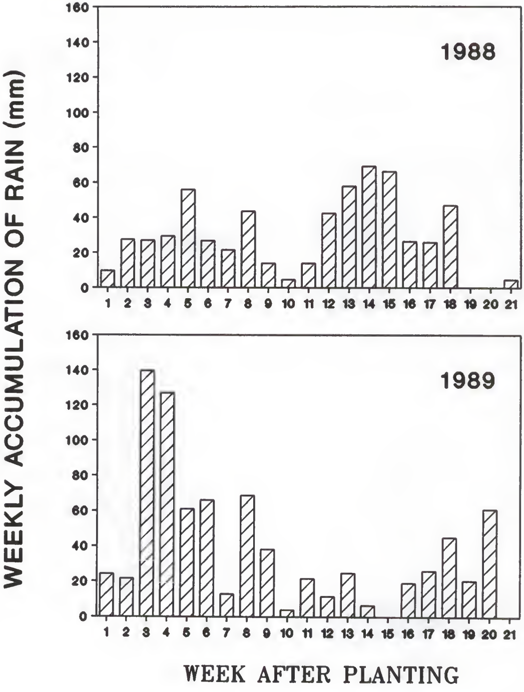

Figure 2-1. Weekly accumulation of rain at the Dozier Boy's School, Marianna, FL during summers of 1988 and 1989.

lesions using a cyclone spore collector. Conidia were suspended in distilled water and diluted to 10,000 spores/ml. Conidial concentrations were determined with a hemocytometer. Inoculation was made with a Spra Tool (Fisher Scientific Products, Pittsburgh, PA) calibrated to deliver 1 ml of inoculum per tetrafoliate leaf. The target leaf was held flat on a wooden board and the adaxial surface was sprayed with the spore suspension for one second. Due to a large number of target leaves involved, inoculations were not done on the same day. In 1988, inoculations were made on 12 July for replicate 1, on 13 July for replicates 2 and 3 and on 15 July for replicate 4. In 1989, inoculations were made on 23 July for replicates 1 and 2 and on 24 July for replicates 3 and 4. These target leaves were used to monitor the components of resistance for 35 days after each inoculation. Each target leaves were examined every two to three days beginning five days after inoculation. Data were collected on the following components of resistance:

1) incubation period (IP) - number of days from inoculation to the appearance of first lesions,

2) latent period - measured as number of days from inoculation to the first sporulating lesion (LP1), and as number of days from inoculation to 50% of primary lesions sporulating (LP50), calculated with Shaner's probit regression method (41),

3) maximum percentage of lesions that sporulated within 35 days after inoculation (MPLS),

4) lesion size (LS)- mean diameter (mm) of ten mature lesions randomly selected from each tetrafoliate leaf,

5) lesion number (LN) - mean number of lesions per leaf at 25 days after inoculation,

6) degree of sporulation (SP) - amount of sporulation at 25 days after inoculation based on a 1-5 scale, according to Subrahmanyam et al. (49), where 1 = little or no sporulation, 5 = extensive sporulation,

7) percent necrotic area (PNA) per leaf at 25 days after inoculation , estimated visually based on a standard leafspot diagram (45).

Analysis of variance was performed on the means of each component. The number of lesions per leaf were transformed using the square root transformation to normalize the data. Correlations were also computed for the various components of resistance.

Disease Assessments

Late leafspot disease was assessed every 10 to 12 days following the method used by Plaut and Berger (36). Total disease severity was obtained by integrating visible disease (percent necrotic area) with defoliation using the equation:

$$y_t = [(1-d)\ y_v] + d$$

in which y_t represents total disease severity, y_v is the proportion of visible disease (percent necrotic area) and d is the proportion defoliation. Visual assessment of percent necrotic area was based on a standard leafspot diagram (58). This visible disease was a weighted average of three canopy layers in which the proportions of upper, middle, and lower canopy layer were 1/9, 3/9, and 5/9 respectively (34). Defoliation was measured by counting the number of nodes with missing leaflets and the total number of nodes on the main stem of five randomly selected plants in each row.

Disease severity data were transformed by the logistic and Gompertz transformations. The Gompertz and logistic models were fitted to the data (6, 28). The apparent infection rate was estimated from the slope obtained by regressing transformed disease severities against time.

Areas under disease progress curves (AUDPC) were calculated for disease severity following the equation:

$$\text{AUDPC} = \Sigma\ [(y_{i+1} + y_i)/2]\ (t_{i+1} - t_i)$$

where y_i is disease severity at the i^{th} observation and t_i is the time of the i^{th} observation in days after planting.

Differences in the AUDPC's were examined using analysis of variance and orthogonal contrasts. From the values of components of resistance obtained from data on target leaves, the relative contributions of each component towards the reduction of the apparent infection rate were determined using factor analysis. A stepwise regression procedure was used to identify which resistance component best predicted resistance in the field. Statistical analysis were performed utilizing SAS and JMP softwares (SAS Institute Inc., Cary, NC) on microcomputers.

Results

Components of Partial Resistance

The components of resistance estimated from the inoculated target leaves in the field during 1988 and 1989 are shown in Tables 2-3 and 2-4, respectively. Genotypes are listed based on descending values for maximum percentage of lesions that sporulated (MPLS). Except for Florunner, Southern Runner, and UF 81206, genotypes evaluated for these tests were refered to as GT 2 to GT 12 (see Table 2-1).

Incubation period (IP)

The time between inoculation and initial appearance of lesions was not significantly different among the fourteen genotypes evaluated for both years. The mean incubation period ranged from 9.2 to 10.8 in 1988 and 9.1 to 10.9 in 1989.

Latent period (LP)

Latent period was determined as the number of days from inoculation to when the first lesion was sporulating (LP1), and as number of days from inoculation until when 50% of the primary lesions were sporulating (LP50). An LP50 could not be determined for nine (UF 81206 and genotypes 2, 3, 4, 5, 8,

Table 2-3. Mean values of components of resistance to late leafspot estimated under field conditions during 1988.[a]

Genotype	IP (days)	LP1 (days)	MPLS (%)	LS (mm)	LN	SP	PNA (%)
Florunner	9.6	20.5	81.9	3.7	113.6	3.8	5.8
GT 9	10.8	22.5	72.6	3.2	112.5	3.1	6.1
GT 6	9.7	24.2	58.5	3.4	121.5	2.9	5.2
GT 7	10.2	28.6	39.3	3.4	89.1	3.1	5.2
S. Runner	9.2	24.1	36.9	3.1	99.7	3.3	4.9
GT 12	9.4	29.5	22.6	2.8	99.6	2.3	5.2
GT 5	9.5	27.5	21.6	2.8	94.1	2.1	4.4
GT 3	9.6	32.1	20.1	3.2	76.3	2.5	5.1
GT 4	10.5	29.7	18.9	2.6	96.5	2.2	5.2
GT 11	9.5	31.6	17.2	2.7	89.1	2.5	4.7
GT 2	10.1	32.4	17.1	3.1	81.7	2.3	4.6
UF 81206	10.3	33.9	14.8	2.9	79.3	2.1	4.8
GT 10	10.5	29.8	13.8	2.9	84.2	2.4	4.7
GT 8	10.1	27.4	13.1	2.9	101.2	2.1	4.9
LSD	NS	3.2	10.1	0.8	NS	0.6	0.2

[a] Components of resistance were obtained from inoculated target leaves in the field (IP = incubation period, LP1 = latent period, MPLS = maximum percentage of lesions that sporulated within 35 days after inoculation, LS = lesion size, LN = number of lesions per leaf, SP = degree of sporulation (1-5 scale), PNA = percent necrotic area per leaf).

Table 2-4. Mean values of components of resistance to late leafspot estimated under field conditions during 1989.[a]

Genotype	IP (days)	LP1 (days)	MPLS (%)	LS (mm)	LN	SP	PNA (%)
Florunner	9.8	22.6	93.6	4.2	89.7	4.3	5.1
GT 9	10.7	22.9	89.1	3.5	92.8	3.8	4.8
GT 7	10.1	23.6	80.7	3.4	81.2	3.1	5.2
S. Runner	10.2	24.8	76.5	3.1	64.5	3.4	4.9
GT 6	10.4	21.8	74.3	4.3	87.6	2.6	5.1
GT 5	9.6	24.3	34.5	2.9	81.9	2.1	4.6
GT 4	9.4	26.7	33.9	2.8	59.9	2.4	3.9
GT 10	9.9	27.3	24.5	2.9	58.2	2.5	3.1
GT 3	10.5	28.5	22.6	2.9	65.4	2.6	3.4
GT 12	10.6	27.9	22.5	2.7	71.4	2.3	3.3
GT 11	10.9	30.8	19.8	3.1	78.9	3.1	3.5
GT 2	9.1	31.4	18.7	2.8	88.1	2.4	3.1
UF 81206	9.7	29.9	12.7	2.7	61.9	2.0	3.2
GT 8	10.1	29.1	12.5	2.8	78.4	2.1	3.1
LSD	NS	2.6	11.4	1.1	NS	0.7	0.4

[a] Components of resistance were obtained from inoculated target leaves in the field (IP = incubation period, LP1 = latent period, MPLS = maximum percentage of lesions that sporulated within 35 days after inoculation, LS = lesion size, LN = number of lesions per leaf, SP = degree of sporulation (1-5 scale), PNA = percent necrotic area per leaf).

10, and 11) out of the 14 genotypes, that is, the inoculated leaves turned yellow and dropped from the plants before 50% of lesions had sporulated. Values for LP1 only are shown in both tables. Significant differences in latent period (LP1) were obtained among genotypes for evaluations made in both 1988 and 1989. Mean values of LP1 ranged from 20.5 to 33.9 in 1988 and from 21.8 to 31.4 in 1989. Genotypes UF 81206, GT 2, and GT 11 had the longest latent periods during both years. Florunner and GT 9 had the shortest latent periods during both years.

Maximum percentage of lesions that sporulated (MPLS)

The maximum percentage of lesions that sporulated (MPLS) within 35 days after inoculation were used to rank the genotypes for both years. The MPLS value was obtained by dividing the number of lesions that sporulated by day 35 by the total number of lesions counted on day 25. Genotypes UF 81206, GT 2, and GT 8 had the lowest MPLS for both years. For both UF 81206 and GT 8, fewer than 15% of the total lesions sporulated within the 35-day period from inoculation. Florunner, GT 9 and GT 6 had the highest MPLS for both years.

Lesion size (LS)

The mean diameters of lesions ranged from 2.6 mm to 3.7 mm in 1988 and from 2.7 mm to 4.3 mm in 1989. Some differences in size of lesions were observed among genotypes. Lesions on GT 4, 5, 8, 10, 11, 12, and UF 81206 had significantly smaller diameters than the susceptible standard, Florunner in 1988. In the 1989 test, lesions on these same genotypes again had significantly smaller diameters. The lesions on Southern Runner and GT 3 were smaller than those on Florunner in both years but this difference was only significant in 1989.

Lesion number (LN)

The number of lesions per leaf counted at 25 days after inoculation were not significantly different among the genotypes for both years. There was more variation in number of lesions in 1988 than in 1989. Also, the average number of lesions per leaf was greater in 1988 (95.2) than in 1989 (75.3).

Degree of sporulation (SP)

The degree of sporulation was based on a 1 to 5 scale where 1 = few stromata with little or no sporulation and 5 = dense stromata with extensive sporulation. Differences in degree of sporulation among genotypes were also observed. All genotypes had lower degree of sporulation than Florunner. The lowest sporulation were observed on genotypes 2, 4, 5, 8, 10, 11 and UF 81206.

Percent necrotic area (PNA)

Percent necrotic area (PNA) per leaf was estimated visually based on a standard leaf diagram for late leafspot. There were significant differences in PNA among genotypes. All genotypes had significantly lower percent leaf necrosis than Florunner in 1988, except GT 9. In 1989, all were significantly lower except genotypes 6, 7, 9 and Southern Runner.

Disease Progression and Pod Yield

The mean area under disease progress curves (AUDPC), rates of disease progress, and pod yield in 1988 and 1989 are given in Table 2-5. The genotypes are listed based on a descending order of AUDPC values for 1988.

Disease severities were transformed using both the logistic and Gompertz transformations. The rates shown in the table were estimated from the slope obtained from the linear regression of logistically transformed disease severities against time. The rate of disease progress in 1989 is significantly higher than in 1988. The rates of disease progress in Florunner during 1988 and 1989 were 0.118 and 0.132 respectively. There were significant differences in rates among the genotypes. UF 81206, GT 8, GT 4, and GT 10 exhibited the lowest epidemic rates for both years, while Florunner and GT9 had the highest rates.

Significant differences in AUDPCs were observed among the 14 peanut genotypes. Florunner and GT 9 had the largest AUDPC for both years. UF 81206, GT 8, GT 4, and GT 10 exhibited the smallest AUDPC and no significant difference was obtained among these latter four genotypes. The fourteen genotypes could be grouped into four levels of AUDPC.

Table 2-5. Mean areas under disease progress curve, rates of disease progress, and pod yield from field tests in 1988 and 1989.

Genotype	AUDPC[a] (%-days)		Rate[b] of Disease progress		Yield (kg/ha)	
	1988	1989	1988	1989	1988	1989
Florunner	2153	2484	0.118	0.132	432	2906
GT 9	1126	1463	0.089	0.112	2866	3704
S. Runner	998	1120	0.075	0.091	2896	3344
GT 12	899	789	0.068	0.081	3694	3740
GT 6	779	834	0.049	0.089	2266	3288
GT 11	675	761	0.047	0.069	3679	3684
GT 7	581	792	0.049	0.079	2403	2653
GT 3	458	799	0.051	0.075	2535	2587
GT 2	434	804	0.049	0.077	1976	2485
GT 5	428	809	0.047	0.077	2307	2541
UF 81206	396	481	0.044	0.057	3480	3995
GT 8	381	548	0.041	0.061	1982	2154
GT 4	379	573	0.039	0.064	2108	1992
GT 10	345	487	0.039	0.059	1585	1377
LSD	158	251	0.014	0.013	316	349

[a] AUDPC = area under disease progress curves measured from day 62 to 121 in 1988 and from day 65 to 125 in 1989.

[b] Rates were obtained by regressing logistically transformed disease severities against time (in logits day^{-1}).

Genotypes UF 81206, GT 12, and GT 11 had consistently high pod yield for both years. GT 8, GT 4, and GT 10, which had the lowest AUDPCs also had the lowest yields, in contrast to the high-yielding, resistant line UF 81206.

The coefficients to correlate both AUDPC and rate of disease progress to estimated values of components of resistance are given in Table 2-6. Rates of disease progress and AUDPCs were more highly correlated with MPLS and latent period than with lesion size, amount of sporulation, and percent necrotic area. With a stepwise regression procedure, a combination of MPLS and latent period accounted for about 69% of the variation in observed AUDPC and rates. Factor analysis (principal components analysis) was applied to the correlation matrix among components of resistance and two significant factors were obtained. The first factor was dominated by MPLS and latent period and the second factor with a lower variance was dominated by degree of sporulation and lesion size.

Discussion

The fourteen genotypes evaluated in field tests during 1988 and 1989 were selected from materials examined by Chiteka (8) in 1987. Chiteka quantified components of partial resistance to late leafspot in 116 genotypes under greenhouse

Table 2-6. Pearson correlation coefficients[a] relating components of resistance to AUDPC and rate.

Component[b]	AUDPC[c]		Rate[d]	
	1988	1989	1988	1989
LP1	-0.79**	-0.76**	-0.69**	-0.68**
MPLS	0.81**	0.78**	0.72**	0.74**
LS	0.59	0.63*	0.64**	0.62*
SP	0.69**	0.67**	0.61*	0.49
PNA	0.66**	0.52	0.51	0.54

[a] Coefficients marked by one and two asterisks are statistically significant at $P \leq 0.05$ and 0.01, respectively.

[b] LP1 = latent period; MPLS = maximum percentage of lesions that sporulated within 35 days after inoculation; LS = lesion size; SP = degree of sporulation; PNA = Percent necrotic area per leaf.

[c] AUDPC = area under disease progress curves measured from day 62 to 121 in 1988 and from day 65 to 125 in 1989.

[d] Rates were obtained by regressing logistically transformed disease severities against time (in logits day^{-1}).

and field conditions, examined correlations among components, and determined contribution of each component to an overall plant appearance score. In that study, sporulation, lesion size, and latent period were the most important components that contributed to the visual score for plant appearance. The sporulation score alone accounted for 55% of the total variation. In the present study, the progress of late leafspot disease was monitored in these selected genotypes to examine the effect of components of partial resistance on the rate of disease progress and areas under the disease progress curve.

The time from inoculation to lesion appearance did not differ significantly among genotypes. Watson (58) and Chiteka (8) reported similar findings. This also agrees with the findings of Shew et al (44) that incubation period was more a function of environmental factors such as temperature and humidity) than genotypic differences (44). The same holds true for the number of lesions per leaf. This latter component tends to be affected greatly by temperature and humidity such that differences attributable to genotypes, if they really exist, are easily overshadowed. Latent period, lesion size, percent sporulating lesions, and sporulation capacity of each lesion are the components that clearly differentiate one genotype from another in terms of quantitative resistance.

Both latent period and the maximum percent lesions sporulating (MPLS) were highly correlated with rate of disease progress and AUDPC. Correlations of components with AUDPC were higher than correlation of components with rate of disease progress. This may be because AUDPC gives a better description of the total disease epidemic than does epidemic rate.

With a stepwise regression procedure, the two components, MPLS and latent period, accounted for 69% of the total variation in observed AUDPC and epidemic rate. With a factor analysis, the first factor was dominated by both MPLS and latent period. The second factor with a lower variance consisted of sporulation and lesion size. The two components that had the greatest effect on reducing disease development in the field were MPLS and latent period. The MPLS parameter was particularly useful to determine genotypes with high partial resistance because the LP50 (latent period measured at 50% of lesions sporulating) was difficult to determine in many of these genotypes.

Genotypes with high levels of quantitative resistance may not always have a high yield potential. Examples of these in this study were GT4, GT8, and GT10. However, UF 81206 had a higher level of resistance as expressed in its long latent period, low MPLs, small lesion size, and low amount of sporulation, and yet it had a high potential. This agrees with the findings of other researchers (9, 10, 34, 58). On the other hand, genotypes such as Southern Runner, GT9, and GT6 had much less resistance than UF 81206 and yet maintain similar yields. One possible reason for this is that there may be a component for tolerance in these genotypes in addition to the low levels of resistance. This has been shown to be the case with Southern Runner (35). This genotype was found to have a lower partitioning of photosynthate into reproductive growth than did the late leafspot-susceptible cultivar, Florunner. This tolerant component is apparent in continued leaf production throughout the growing season. New leaves effectively replace those lost earlier to leafspot-induced defoliation.

CHAPTER 3

RELATIONSHIPS AMONG SEVERITY OF LATE LEAFSPOT, RADIOMETRIC MEASUREMENTS, HEALTHY LEAF AREA DURATION, AND POD YIELD IN TWO PEANUT CULTIVARS

Introduction

Serious yield losses in peanut have been attributed to the late leafspot disease, caused by the fungus, Cercosporidium personatum (Berk. & Curt.) Deighton. Late leafspot is the predominant disease in Florida, Georgia, Alabama, and most of Texas (18). High levels of late leafspot disease cause severe defoliation and reduced pod yield (4, 18, 47). Yield losses can be over 50% if adequate control measures are not used (46, 48). These losses have been attributed to a reduction in leaf area index due to leaf necrosis and defoliation. Light interception and canopy photosynthesis are reduced, eventually leading to decreased pod growth (5, 11, 33, 34, 35, 52).

Studies on loss of crop yield often make use of the quantitative relationship between disease intensity and yield. Several models to predict crop loss based on severity of disease have been developed. For certain crops, such as wheat, potatoes, and peanut, yield has been related to the leaf area duration or the integral of leaf area over time (57). This may be a more relevant parameter to utilize than diseased leaf area or disease severity. Waggoner and Berger (54) in 1987 proposed a model to analyze disease-induced yield losses using healthy leaf area duration (HAD) or the integrals of healthy leaf area over time. They concluded that HAD can be used to predict pod yield of diseased peanut crop. HAD values can be computed using estimates of leaf area index and disease severity during the cropping season.

Since measurements of leaf area are very tedious and usually require destructive sampling, the use of radiometric techniques may be a better alternative. Previous workers have shown that spectral reflectance can provide a good estimate of healthy, green leaf area. Nutter (31) reported that percent reflectance of a peanut crop canopy at 800 nm wavelength provided a rapid and objective means to measure disease intensity and he suggested that it is representative of the amount of green leaf area. However, he did not determine the leaf area index in his research. In other studies, researchers have demonstrated the use of spectral radiometry to determine the severity of disease (43) and to estimate defoliation (20).

Objectives of this study were 1) to determine the relationships among disease severity, canopy reflectance, healthy leaf area duration, and pod yield, to find whether yield is simply determined by the duration of healthy leaf area (HAD) and 2) to determine whether peanut canopy reflectance can provide a good estimate of amount of green leaf area and disease severity.

Materials and Methods

Field Experiments

Field experiments were conducted during the peanut growing seasons in 1988 and 1989 at the Agricultural Research Center at Marianna, Florida. Standard agronomic and cultural practices for peanut production were carried out for both seasons. Six-row plots were utilized with each row measuring 6.1 m long on 0.91-m centers. The two innermost rows (rows 3 and 4) in each plot were used to obtain yield data. Measurements of irradiation reflectance and leaf area index (LAI) were made on rows 2 and 5. The 1988 peanut crop received irrigation using overhead sprinklers while the 1989 peanut crop was irrigated with a center pivot system. The amount of rain received during the season are shown in Figure 3-1. The amount of rain shown for 1989 includes irrigation.

During the 1988 cropping season, Florunner, a cultivar susceptible to late leafspot, was planted on 5 May in a randomized complete block design with four replications. To establish several classes of disease levels, spray treatments of chlorothalonil were used. Six treatments of sprays applied at 14-day interval were as follows; (1) spray beginning 35 days after planting (growers schedule), (2) an unsprayed

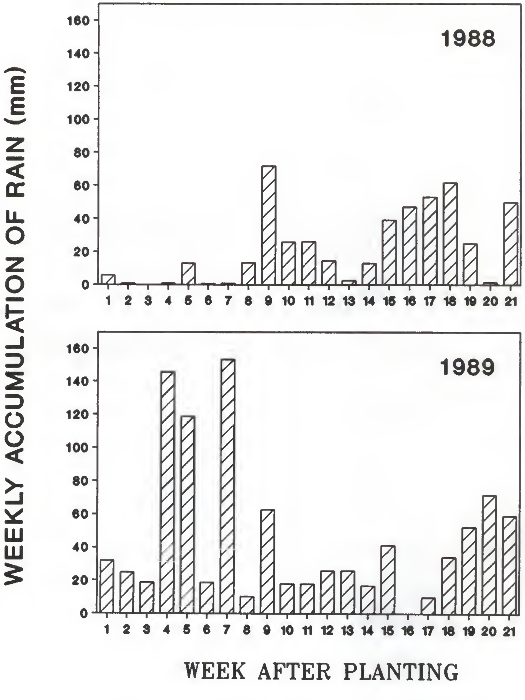

Figure 3-1. Weekly accumulation of rain in Marianna, FL during summers of 1988 and 1989. Irrigation is included in 1989.

control, and four treatments initiated at 1.0 % leafspot incidence; i.e., (3) 0.13 X, (4) 0.25 X, (5) 0.5 X, and (6) 1.0 X in which X is the recommended rate of 1.5 pt/A Bravo 720 (720 g ai/liter, flowable formulation).

Peanut plots were dug on 27 September using a digger-shaker-inverter. After drying in windrows for three days, pods were harvested with a small plot thresher and dried to 10% moisture content for determination of pod yields.

For the 1989 field experiment, two cultivars were used; Florunner and Southern Runner, a cultivar known to have a moderate resistance to late leafspot. They were planted on 15 May 1989 in a split-plot randomized complete block design with cultivars as main plots and fungicide treatments as subplots. There were five fungicide treatments applied on 14-day intervals as follows: (1) growers schedule beginning 35 days after planting, (2) an unsprayed control, and three treatments initiated at 0.5 % leafspot incidence; i.e., (3) 0.25 X, (4) 0.5 X, (5) 0.75 X, in which X is the recommended rate. Fungicide applications were made using a CO_2-powered, tractor-mounted sprayer equipped with three D2-45 nozzles per row at 2 kg/cm^2 of pressure. Peanut plots were harvested on 29 September and pod yield was determined as in the previous year.

Disease Assessments

To assure establishment of a late leafspot epidemic, inoculum was introduced by applying peanut plant debris one month after planting. Approximately 50 g of chopped peanut stems from the previous year's crop were scattered on each sixth plot row. The experimental areas for both years had not been planted with peanut in the previous season. Assessments were made at 10 to 12-day intervals and during leaf area sampling. Severity of late leafspot was assessed based on a combined measurement of percent necrotic area and percent defoliation following the method used by Plaut and Berger (36). Visual assessment of percent necrotic area was based on a standard leafspot diagram (45). This visible disease was a weghted average of three canopy layers (34). Percent defoliation was obtained by counting the number of nodes with missing leaflets and the total number of nodes on the stem of five randomly selected plants. Total disease severity was obtained by integrating visible disease (percent necrotic area) with defoliation using the equation:

$$y_t = [(1-d)\ y_v] + d$$

in which y_t represents total disease severity, y_v is the proportion of visible disease (percent necrotic area) and d is the proportion defoliation. Severity values were logistically transformed and subjected to analysis of variance for each individual assessment. The apparent infection rate was considered as the slope of the linear regression line.

Radiometric Measurements

The amount of sunlight reflected from peanut canopies was measured throughout the season at 10 to 12-day interval. Percent reflectance of sunlight in the 800 nm wavelength was monitored using a hand-held multispectral radiometer (CROPSCAN, Inc., Fargo, ND). Measurements of percent reflectance were taken from a height of approximately 1.6 m above the peanut canopy. The support pole of the radiometer sensor was leaned over the plot. A bubble spirit level (attached to the main module) was used to ensure that the sensor is at right angle view. Two sample readings from two inner rows in each plot were automatically averaged and recorded. Readings were made during adequate sunlight conditions between 1100 and 1500 hrs EST. The radiometer has sensors to detect incoming radiation and comparator circuitry to compare this with the canopy reflectance, thus adjusting for minor changes in sunlight due to differing conditions and time.

Leaf Area Index (LAI) and Healthy Leaf Area Duration (HAD)

Leaf area index (LAI) was measured eight times during the season for both years by harvesting 0.91 sq. m. in each plot. Leaf area was measured using a leaf area meter (Li-Cor, Inc., Lincoln, NE). The LAI was calculated as:

LAI = specific leaf area x fraction leaf x biomass where specific leaf area is the ratio of leaf area to leaf mass. Specific leaf area and fraction leaf were measured from a single plant taken from each sampling area. Biomass is the total dry weight of plants from the sampling area including the subsampled single plant (34).

Green leaf area index (GLA) was computed based on the equation: $GLA_i = (1-y_i)\ L_i$

where y_i is the proportion of diseased or necrotic area and L_i is leaf area index of sample i. Healthy leaf area duration (HAD) was calculated using the equations given by Waggoner and Berger (54) as follows:

$$HAD = \Sigma\ \{[(1-y_i)L_i + (1-y_{i-1})L_{i-1}]\ (t_i - t_{i-1})/2\}$$

where y_i, L_i, t_i are, respectively, the proportion of diseased area, the leaf area index, and the time of sampling in days.

Results

Disease Progression

The experimental fields of 1988 and 1989 were infected by Cercospora arachidicola Hori early in the season. However, it was negligible and late leafspot quickly became the predominant disease. The logistically transformed disease progress curves for cultivars Florunner and Southern Runner are shown in Figures 3-2, 3-3, and 3-4. Logit (Y) represents logit of total disease severity which is the combined assessments for disease and proportion defoliation.

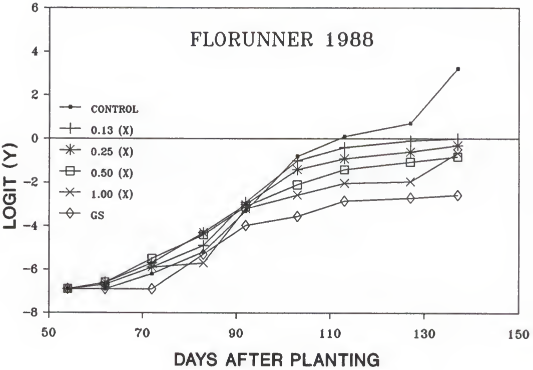

Figure 3-2. Progression of late leafspot in Florunner in 1988 under different fungicide treatments (an unsprayed control, four spray rates initiated at 1% incidence where X = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP). Logit (Y) represents logistically transformed disease severity.

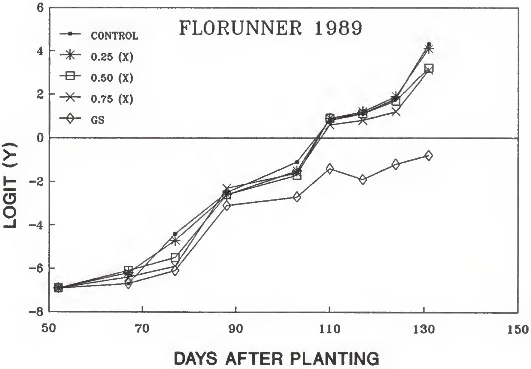

Figure 3-3. Progression of late leafspot in Florunner in 1989 under different fungicide treatments (an unsprayed control, three spray rates initiated at 0.5% incidence where X = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP). Logit (Y) represents logistically transformed disease severity.

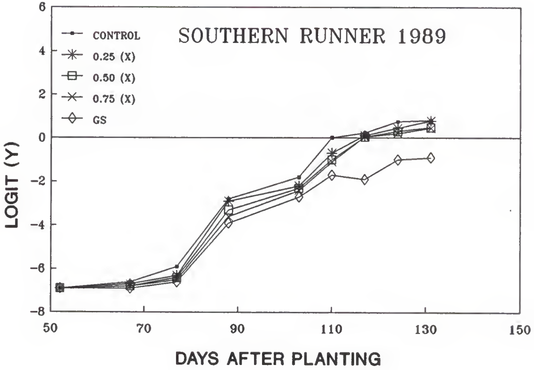

Figure 3-4. Progression of late leafspot in Southern Runner in 1989 under different fungicide treatments (an unsprayed control, three spray rates initiated at 0.5% incidence where X = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP). Logit (Y) represents logistically transformed disease severity.

In 1988, the rate of disease progress for the unsprayed control was 0.108 compared to sprayed (growers schedule) treatment which was 0.039. The growers schedule treatment was initiated 35 days after planting during which time the disease had not yet begun. The epidemic rates for the other treatments where spray was initiated at 1% disease incidence were 0.047 (1.0X), 0.048 (0.5X), 0.055 (0.25X), and 0.061 (0.13X).

In 1989, the rate of disease progress for untreated Florunner was 0.150 while the sprayed (growers schedule) treatment was 0.047. The epidemic rates for treatments 0.25 X, 0.5 X, and 0.75 X were 0.149, 0.138, and 0.121 respectively. Compared to untreated Florunner, the rate of disease progress for untreated Southern Runner was much slower (0.09). The sprayed (growers schedule) treatment for Southern Runner had an epidemic rate of 0.046. The rates for the other treatments were essentially identical (0.082 for 0.25 X, 0.081 for 0.50 X, and 0.082 for 1.00 X).

Leaf Area Index

The changes in leaf area index for Florunner in 1988, 1989 and Southern Runner in 1989 are presented in Figures 3-5, 3-6, 3-7. During the 1988 season, for Florunner, there were no differences in leaf area index among the treatments until after 100 DAP. The sprayed (growers schedule) treatment had an LAI of 3.8 at 113 DAP and it was significantly different from the other treatments.

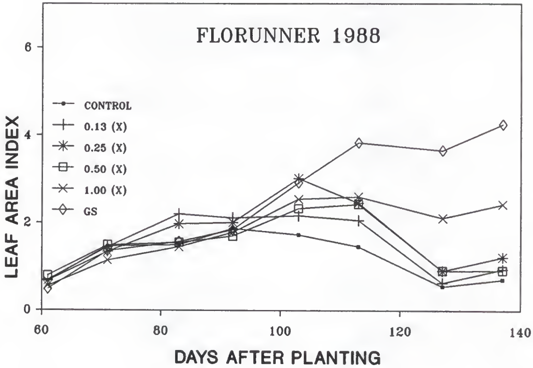

Figure 3-5. Leaf area index over time for Florunner in 1988 under different fungicide treatments (an unsprayed control, four spray rates initiated at 1% incidence where X = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP).

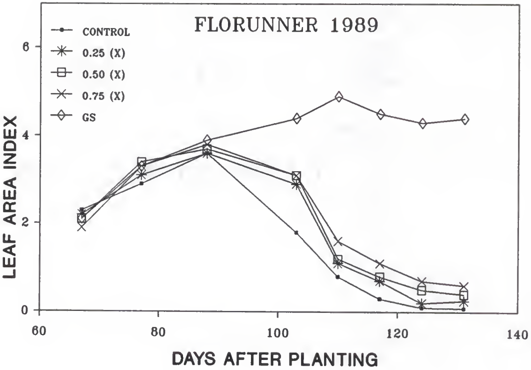

Figure 3-6. Leaf area index over time for Florunner in 1989 under different fungicide treatments (an unsprayed control, three spray rates initiated at 0.5% incidence where X = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP).

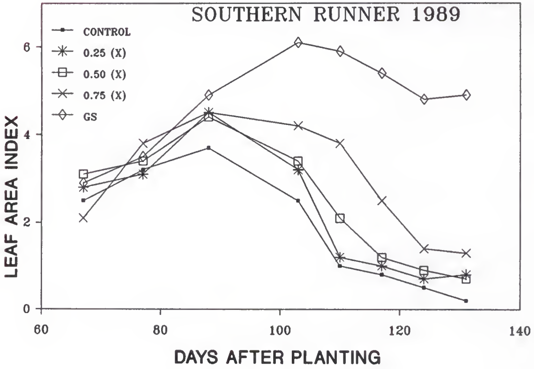

Figure 3-7. Leaf area index over time for Southern Runner in 1989 under different fungicide treatments (an unsprayed control, three spray rates initiated at 0.5% incidence where X = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP).

The peanut crop in 1989 attained a higher leaf area index (LAI) than the crop in 1988. For both Florunner and Southern Runner, the differences in LAI among treatments became evident only after 88 DAP. In 1989, Florunner under the 14-day growers schedule spray treatment reached a maximum LAI of 5.0 at 110 DAP. Southern Runner that received the spray (growers schedule) treatment attained a maximum LAI of 6.1 at 103 DAP. For all the other spray treatments and unsprayed control, the LAI declined drastically as late leafspot became severe. LAI higher than 2 was maintained only on plots that received growers schedule treatment.

Green Leaf Area and Percent Reflectance

The crop in 1988 started at lower reflectance values at 800 nm (Fig. 3-8) compared to the crop in 1989 (Figs. 3-9, and 3-10). The crop in 1989 had better vegetative growth and higher LAI values. Percent reflectance values decreased as disease severity and defoliation increased during the season, except for treated (growers schedule) plots where values remained relatively similar throughout the season. During 1988, Florunner plots that received the spray (growers schedule) treatment was significantly different from the other five treatments at 114 DAP. Linear relationships (Figures 3-11, 3-12, and 3-13) were obtained between green leaf area and percent reflectance of canopy for both Florunner and Southern Runner.

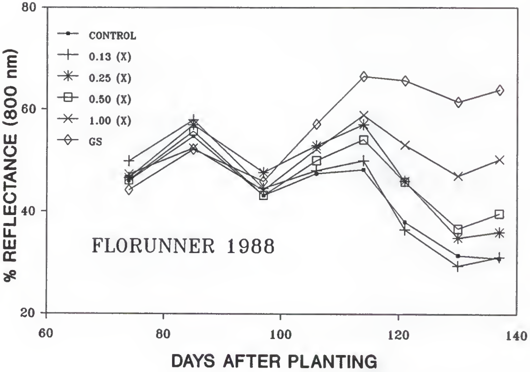

Figure 3-8. Percent Reflectance at 800 nm for Florunner in 1989 under different fungicide treatments (an unsprayed control, four spray rates initiated at 1% incidence where X = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP).

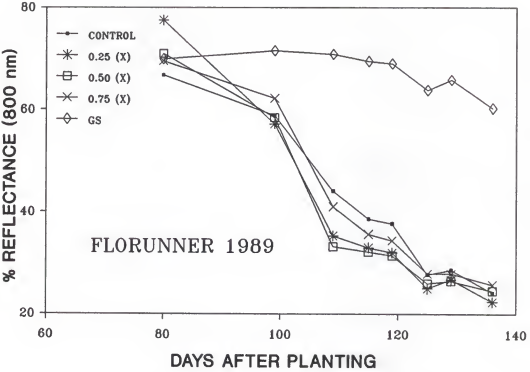

Figure 3-9. Percent reflectance at 800 nm for Florunner in 1989 under different fungicide treatments (an unsprayed control, three spray rates initiated at 0.5% incidence where X = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP).

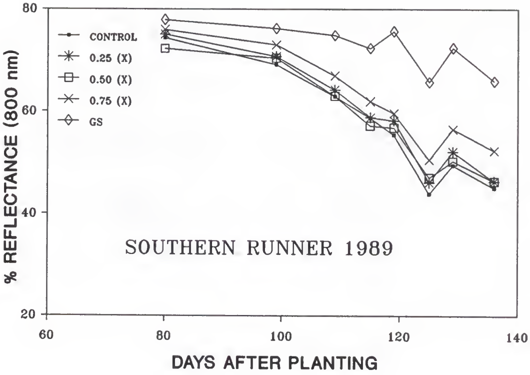

Figure 3-10. Percent reflectance at 800 nm for Southern Runner in 1989 under different fungicide treatments (an unsprayed control, three rates initiated at 0.5% incidence where X = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP).

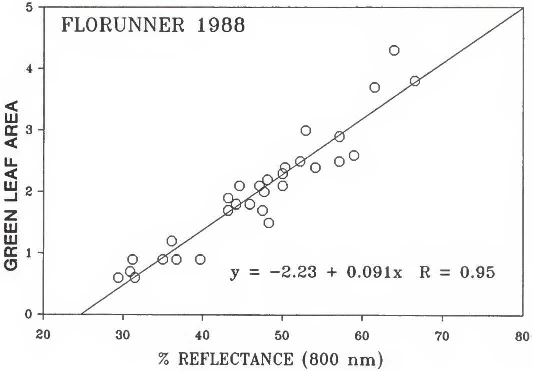

Figure 3-11. Relationship between percent reflectance at 800 nm and green leaf area (GLA) of Florunner in 1988.

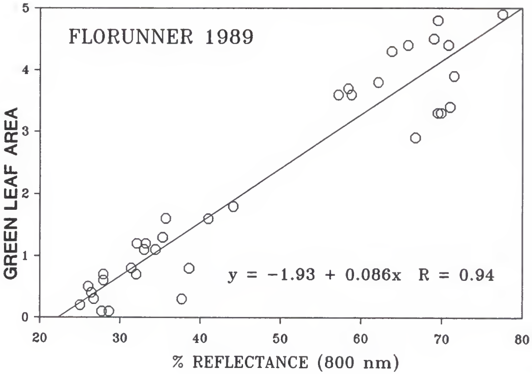

Figure 3-12. Relationship between percent reflectance at 800 nm and green leaf area (GLA) of Florunner in 1989.

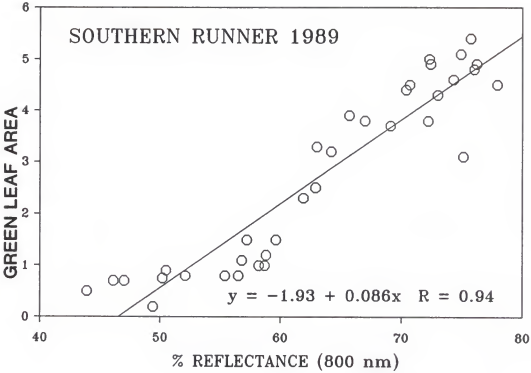

Figure 3-13. Relationship between percent reflectance at 800 nm and green leaf area (GLA) of Southern Runner in 1989.

Healthy leaf Area Duration (HAD) and Pod Yield

The relationship between HAD and pod yield for Florunner during 1988 and 1989 and Southern Runner during 1989 season is given in Figure 3-14. The drawn curve represents the Gompertz equation developed by Waggoner and Berger (54),

$$\text{Yield} = 735 \exp\{-3.15 \exp[-0.00821\ (\text{HAD}-93.71)]\}$$

Each point in the graph represents a treatment in the field tests during 1988 and 1989 for both Florunner and Southern Runner. For instance, the sprayed (growers schedule) treatment for Florunner during 1988 had a yield of 353 g/m^2 and an HAD of 270 LAI-days. The sprayed (growers schedule) Florunner plots in 1989 yielded 585 g/m^2 with an HAD of 386 LAI-days. For Southern Runner, the sprayed (growers schedule) plots had a yield of 577 g/m^2 and HAD of 425 LAI- days.

Discussion

In the 1988 field test for Florunner, six treatments were designed to establish different levels of disease epidemics. However, only four distinct disease levels could be discerned as shown in Figure 3-2. This was also true with 1989 test, where 0.25X, 0.5X, and 0.75X spray treatments did not give significantly different disease levels from untreated control. Nevertheless, the number of disease levels obtained were adequate for the purpose of this study.

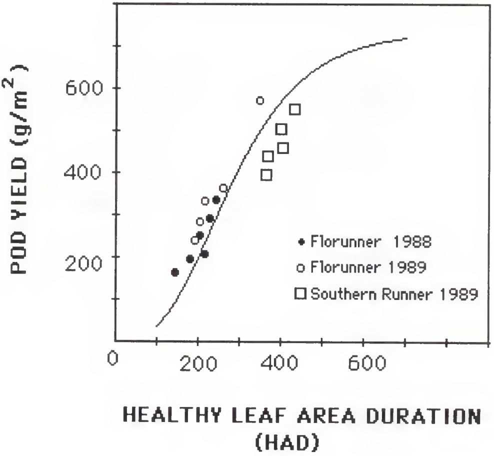

Figure 3-14. Relationship between healthy leaf area duration (HAD) and pod yield for Florunner in 1988 and 1989 and southern Runner in 1989. The curve represents the Gompertz equation (from Waggoner and Berger, 1987):

Yield = 735*exp{-3.15*exp[-0.00821*(HAD-93.71)]}.

The peanut crop in 1989 attained a higher leaf area index than the crop in 1988. There are two possible reasons for this. In 1988, watering was more difficult due to the low-pressure, overhead-sprinkler system used. Peanuts therefore received less water at each irrigation. A second factor was a build-up of root-knot nematodes during the season. Aldicarb could not be used due to close proximity to a water well. Nemacure, the nematicide used, did not adequately control the nematode population. Plots of Florunner and Southern Runner in 1989 had a maximum LAI of 4.9 and 6.1 respectively. The 1989 crop received consistent irrigation compared to 1988 crop where irrigation was irregular and crop development as well as disease progress were delayed.

In 1988, the rate of leafspot epidemic ranged from 0.039 to 0.108 and in 1989, from 0.047 to 0.15. Alderman et al. (2) reported rates for late leafspot epidemic ranging from 0.02 to 0.25 logits day^{-1}. During the 1989 season, the rate of progression for late leafspot (0.15) for untreated Florunner was higher than the previous year (0.108). The rate of disease progress in untreated Southern Runner was significantly slower than that of untreated Florunner. Southern Runner is known to possess rate-reducing resistance and the ability to produce more leaves (17, 33, 34, 35, 58).

Percent reflectance (800 nm) ranged from 25% in a defoliated crop to 75% in a full canopy crop. Reflectance for untreated Florunner at the end of the season averaged 25% while values for untreated Southern Runner averaged 45%. There is a strong relationship between reflectance values and green leaf area. In this study, percent reflectance at 800 nm was highly correlated with green leaf area. Green leaf area values were obtained by subtracting proportion of diseased area from the leaf area index of the total canopy. Based on the linearity of relationships obtained and the high coefficients of determination, (0.95 for Florunner in 1988, 0.96 for Florunner in 1989 and 0.95 for Southern Runner in 1989), canopy reflectance data can be used as reliable representation of green leaf area. This agrees with the hypothesis of Nutter (31) that the radiometer, using the 800 nm wavelength, is actually measuring healthy green leaf area. Canopy reflectance would then be useful in screening peanut genotypes for resistance to late leafspot and also, in evaluation of disease control methods such as experimental fungicides.

HAD values obtained from estimates of leaf area index and disease proportion were used to predict pod yield. With the equation developed by Waggoner and Berger (54), the predictions were adequate for 1988 and 1989 Florunner crop. Of the 11 treatments, 10 had actual yield above the predicted yield but fell within the variation set by the equation. With Southern Runner, prediction of yield was overestimated. This may be due to the fact that the equation was developed from manually-defoliated Florunner peanuts and not from Southern Runner. This may also indicate that the characteristic of a variety affects the relationship between HAD and pod yield. Southern Runner had higher HAD values than Florunner at comparable yield levels. This may mean that the ability of Southern runner to produce more leaves may have affected its proportional allocation of photosynthate used for pod growth.

CHAPTER 4
SUMMARY

The studies reported here on late leafspot of peanut dealt with two epidemiological aspects, one on quantitative resistance and the other, on disease development and healthy leaf area duration (HAD).

The form of resistance currently available for late leafspot disease of peanut is of the rate-reducing type. In examining the fourteen genotypes for components of partial resistance, the most resistant ones exhibited longer latent period and lower maximum percent of sporulating lesions. For instance, UF 81206 had an average latent period (LP1) of 31 days compared to susceptible Florunner which had an average latent period (LP1) of 21 days. Adding to the ten- day difference in latent period is the fact that less than 15% of leafspot lesions in resistant line UF 81206 sporulated within a 35-day period. Latent period and the maximum percent lesions sporulating (MPLS) and degree of sporulation were more highly correlated with rate of disease progress and AUDPC than lesion size and percent necrotic area per leaf. The two components that contributed heavily toward reducing the rate of disease progress were latent period and MPLS. Thus, emphasis should then be given on these two components when screening for resistance to late leafspot in peanut germplasms and breeding lines.

Canopy reflectance at 800 nm was found to be highly correlated with green leaf area. Percent reflectance can be used as an estimate of healthy green leaf area. Thus, the radiometer can provide an easy, rapid, and objective means of measuring healthy green leaf area of a peanut canopy.

Healthy leaf area duration (HAD) as a predictor of yield was tested using the equation developed by Waggoner and Berger (54) derived for manually-defoliated Florunner peanuts. Predictions were adequate for Florunner crops during 1988 and 1989. Predicted yield of Southern Runner, however, was overestimated. Southern Runner is a variety that produces more leaves compared to Florunner. Also, Southern Runner possesses a certain level of resistance to late leafspot and thus, retains more foliage than Florunner. Due to these difference in characteristics, the relationship of HAD to pod yield in Southern Runner differs from that of Florunner.

APPENDIX A
WEATHER DATA

Table A-1. Weather data during summer 1988 at AREC (Agricultural Reasearch Center), Marianna, Florida.

Month	Day	Maximum Temp. °C	Minimum Temp. °C	Rain mm
5	2	25.6	8.3	5.6
5	3	28.3	10.0	0.0
5	4	28.9	10.0	0.0
5	5	29.4	12.8	0.0
5	6	26.1	10.6	0.0
5	9	30.6	10.0	0.0
5	10	30.6	16.1	0.0
5	11	32.2	16.7	0.8
5	12	31.1	12.8	0.0
5	13	32.2	17.2	0.0
5	16	33.3	13.3	0.0
5	17	34.4	20.6	0.0
5	18	34.4	13.9	0.0
5	19	33.3	13.9	0.0
5	20	32.8	13.3	0.0
5	23	34.4	13.9	0.0
5	24	33.9	20.0	0.0
5	25	35.0	18.3	0.8
5	26	30.0	16.7	0.0
5	27	28.3	8.9	0.0
5	30	34.4	8.9	0.0
5	31	35.0	16.1	0.0
6	1	34.4	14.4	0.0
6	2	35.0	17.2	0.0
6	3	36.1	17.2	0.0
6	6	35.0	17.2	11.2
6	7	28.3	20.6	1.5
6	8	31.1	19.4	0.5
6	9	33.9	20.0	0.0
6	10	33.9	21.1	0.0
6	13	31.1	14.4	0.0
6	14	32.2	16.7	0.0
6	15	33.3	18.9	0.0
6	16	33.9	16.7	0.0

Table A-1. -- continued.

Month	Day	Maximum Temp. °C	Minimum Temp. °C	Rain mm
6	17	35.6	19.4	0.0
6	20	36.7	17.2	0.8
6	21	36.1	20.0	0.0
6	22	36.1	20.6	0.0
6	23	34.4	22.2	0.0
6	24	35.6	21.7	0.0
6	27	38.3	21.1	6.6
6	28	38.3	22.2	6.6
6	29	33.9	23.9	0.0
6	30	36.7	25.0	0.0
7	1	32.2	22.2	25.1
7	4	33.3	21.1	34.3
7	5	30.6	21.7	4.3
7	6	30.6	21.1	7.9
7	7	31.1	20.0	0.0
7	8	32.2	17.2	0.0
7	11	35.0	19.4	15.5
7	12	28.9	22.8	10.2
7	13	33.9	21.1	0.0
7	14	34.4	22.2	0.0
7	15	34.4	23.9	0.0
7	18	35.0	21.7	15.0
7	19	33.9	22.2	0.0
7	20	32.2	21.1	11.2
7	21	33.3	22.8	0.0
7	22	32.2	21.1	7.9
7	25	32.8	20.0	6.6
7	26	33.9	21.1	0.0
7	27	33.9	22.2	0.0
7	28	33.3	20.6	0.0
7	29	32.2	20.6	0.0
8	1	36.1	20.6	0.0
8	2	35.0	22.2	2.5
8	3	34.4	22.2	0.0
8	4	33.3	21.1	0.0
8	5	33.9	22.2	0.0
8	8	35.0	21.1	3.6
8	9	32.2	21.7	0.0
8	10	34.4	21.7	0.0
8	11	35.0	22.2	3.3
8	12	34.4	22.8	5.8
8	15	35.0	22.2	13.0

Table A-1. -- continued.

Month	Day	Maximum Temp. °C	Minimum Temp. °C	Rain mm
8	16	29.4	22.2	0.3
8	17	33.3	22.8	2.3
8	18	34.4	22.2	1.0
8	19	34.4	22.2	5.3
8	22	35.0	21.1	17.0
8	23	33.9	21.7	0.3
8	24	33.9	22.8	13.2
8	25	33.9	22.2	1.8
8	26	33.9	21.1	0.0
8	29	35.6	20.0	1.8
8	30	35.0	22.2	31.8
8	31	34.4	21.1	0.0
9	1	32.8	21.1	0.3
9	2	28.9	22.8	0.0
9	4	31.7	20.6	52.3
9	6	26.7	17.8	0.3
9	7	28.9	15.6	0.0
9	8	26.7	17.8	1.5
9	9	19.4	16.1	57.2
9	12	32.2	18.3	2.8
9	13	32.8	21.7	0.0
9	14	32.2	20.0	0.0
9	15	32.8	21.1	0.0
9	16	30.6	23.3	10.7
9	19	32.8	20.6	6.6
9	20	32.2	21.1	7.6
9	21	33.3	22.8	0.0
9	22	34.4	20.0	0.0
9	23	33.3	19.4	0.0
9	26	35.0	21.1	0.0
9	27	33.9	21.7	1.3
9	28	28.3	18.3	0.0
9	29	30.0	17.2	0.0
9	30	32.2	20.6	0.0
10	3	32.2	16.7	47.8
10	4	28.3	15.6	2.0
10	5	23.9	12.2	0.0
10	6	25.0	10.6	0.0
10	7	25.6	10.0	0.0
10	10	23.9	5.0	0.0
10	11	25.0	9.4	0.0
10	12	25.6	11.1	0.0
10	13	25.0	7.2	0.0

Table A-1. -- continued.

Month	Day	Maximum Temp. °C	Minimum Temp. °C	Rain mm
10	14	20.6	2.2	0.0
10	17	27.8	5.6	0.0
10	18	28.3	10.0	0.0
10	19	29.4	13.3	0.0
10	20	27.8	15.0	0.0
10	21	26.1	14.4	0.0
10	23	28.9	3.9	0.0
10	24	26.7	13.9	0.0
10	25	25.6	3.3	0.0
10	26	25.6	5.0	0.0

Table A-2. Weather data during summer 1989 at AREC (Agricultural Reasearch Center), Marianna, Florida.

Month	Day	Maximum Temp. °C	Minimum Temp. °C	Rain mm
5	1	30.6	18.9	32.0
5	2	24.4	14.4	49.3
5	3	27.2	11.1	0.0
5	4	26.7	12.2	0.0
5	5	30.6	17.2	4.8
5	8	30.6	7.8	0.0
5	9	27.8	12.2	0.0
5	10	29.4	18.9	1.3
5	11	25.0	10.0	34.3
5	12	25.0	8.9	0.0
5	15	28.3	10.6	0.0
5	16	31.1	16.7	0.0
5	17	30.6	17.2	0.0
5	18	32.2	18.9	7.1
5	19	31.7	19.4	24.6
5	22	31.1	17.2	1.5
5	23	31.7	18.3	0.0
5	24	30.0	17.8	22.9
5	25	32.2	19.4	0.3
5	26	33.3	23.3	0.0
5	29	35.0	20.0	0.0
5	30	31.7	20.6	0.0
5	31	32.2	21.1	0.0
6	1	34.4	21.1	0.0
6	2	35.0	22.2	0.0
6	5	35.6	19.4	0.8
6	6	31.1	20.6	7.6
6	7	28.3	18.3	10.2
6	8	31.7	19.4	23.4
6	9	26.7	18.9	122.2
6	12	33.9	20.0	0.0
6	13	33.3	22.2	0.0
6	14	33.9	22.2	0.0
6	15	34.4	23.9	68.3
6	16	30.6	21.1	50.3
6	19	33.9	19.4	0.0
6	20	30.6	20.6	24.1
6	21	30.0	20.6	2.3
6	22	31.1	20.6	15.2
6	23	31.1	20.0	1.0

Table A-2. -- continued.

Month	Day	Maximum Temp. °C	Minimum Temp. °C	Rain mm
6	26	33.9	20.6	0.0
6	27	33.9	21.1	0.0
6	28	34.4	21.7	0.0
6	29	33.9	21.7	0.5
6	30	32.8	21.7	1.8
7	3	31.7	20.6	65.3
7	4	31.1	21.7	32.3
7	5	31.1	20.6	18.8
7	6	28.9	22.2	32.8
7	7	31.1	22.2	3.0
7	10	34.4	21.7	1.3
7	11	35.0	22.8	0.0
7	12	35.0	22.8	0.0
7	13	34.4	22.8	0.0
7	14	35.0	21.7	10.2
7	17	31.7	21.1	34.0
7	18	32.2	21.7	0.0
7	19	33.9	22.8	0.0
7	20	31.7	23.3	5.8
7	21	30.6	20.6	22.9
7	24	30.6	20.0	38.4
7	25	31.7	20.6	12.7
7	26	33.3	22.8	6.9
7	27	33.3	21.1	0.0
7	28	33.3	22.8	0.0
7	31	35.6	22.2	0.0
8	1	34.4	22.8	17.8
8	2	33.9	22.8	0.0
8	3	33.9	22.2	0.0
8	4	35.0	22.2	0.0
8	7	36.1	22.2	0.0
8	8	36.1	20.6	2.5
8	9	25.6	20.0	15.2
8	10	29.4	20.0	0.0
8	11	26.7	19.4	0.0
8	14	30.6	18.9	0.0
8	15	29.4	20.6	25.7
8	16	30.6	20.6	0.0
8	17	32.2	21.1	0.0
8	18	33.9	21.7	0.0
8	21	35.0	21.1	0.0
8	22	33.9	22.8	0.0
8	23	35.0	22.8	0.0
8	24	36.1	23.3	0.0

Table A-2. -- continued.

Month	Day	Maximum Temp. °C	Minimum Temp. °C	Rain mm
8	25	35.6	23.3	0.5
8	28	37.8	22.8	7.9
8	29	32.8	22.2	8.1
8	30	33.3	22.2	0.0
8	31	35.0	22.8	0.0
9	1	36.1	22.8	5.8
9	4	36.1	22.2	35.6
9	5	30.0	21.1	0.0
9	6	32.2	20.0	0.0
9	7	32.8	21.1	0.0
9	8	33.3	22.2	0.0
9	11	34.4	20.6	0.0
9	12	34.4	20.6	0.0
9	13	33.9	18.9	0.0
9	14	33.9	20.0	0.0
9	15	35.0	21.1	9.7
9	18	33.3	16.7	0.0
9	19	31.7	17.2	0.0
9	20	30.6	14.4	0.0
9	21	29.4	15.0	0.0
9	22	31.1	16.7	0.3
9	25	32.2	14.4	13.2
9	26	20.0	15.6	13.5
9	27	21.1	15.6	0.3
9	28	22.8	17.2	6.9
9	29	22.2	17.8	0.3
10	2	31.1	16.1	51.3
10	3	28.9	16.7	0.8
10	4	30.6	15.6	0.0
10	5	31.7	15.6	0.0
10	6	32.2	17.8	0.0
10	9	32.2	11.1	0.3
10	10	23.9	12.8	0.0
10	11	18.9	11.7	71.4
10	12	27.2	12.8	0.0
10	13	27.8	17.8	0.0
10	16	28.3	17.8	2.5
10	17	31.1	18.9	0.0
10	18	28.9	18.9	54.9
10	19	23.9	9.4	1.8
10	20	10.6	3.3	0.0
10	21	13.3	11.7	0.0
10	23	25.6	12.2	0.0
10	24	24.4	11.1	0.0
10	25	25.6	11.7	0.0

Table A-3. Daily rainfall during summer 1988 at Dozier Boy's School, Marianna, Florida.

Month	Day	Rain mm	Month	Day	Rain mm
5	25	9.7	8	2	7.6
6	4	3.8	8	7	6.4
6	6	15.7	8	10	2.5
6	7	8.1	8	15	2.0
6	8	9.7	8	18	10.2
6	21	17.3	8	21	3.8
6	22	1.5	8	22	3.8
6	27	18.3	8	23	15.7
6	28	9.7	8	25	7.6
7	1	21.1	8	29	10.2
7	2	5.6	9	1	1.3
7	3	20.3	9	3	18.3
7	4	20.3	9	5	38.1
7	5	8.9	9	6	0.5
7	11	14.0	9	9	2.5
7	12	12.7	9	10	63.5
7	18	10.2	9	16	18.3
7	20	11.4	9	17	50.8
7	22	3.8	9	18	3.0
7	25	17.3	9	25	5.6
7	27	2.5	9	27	20.3
7	28	17.8	10	3	47.0
7	31	2.0	10	31	4.6

Table A-4. Daily rainfall during summer 1989 at Dozier Boy's School, Marianna, Florida.

Month	Day	Rain mm	Month	Day	Rain mm
5	20	7.6	8	1	3.8
5	21	22.9	8	8	19.1
5	24	24.1	8	9	2.5
6	5	2.5	8	15	10.2
6	6	10.2	8	18	1.3
6	7	8.9	8	22	1.3
6	8	12.7	8	27	5.1
6	9	127.0	8	28	15.2
6	16	45.7	8	29	3.0
6	17	61.0	9	1	2.5
6	18	1.3	9	2	2.5
6	20	15.2	9	3	1.3
6	21	3.8	9	16	19.1
6	22	12.7	9	25	12.7
6	23	4.6	9	26	11.7
6	26	2.5	9	27	1.3
6	27	2.5	9	28	0.3
6	28	10.2	10	1	41.9
6	30	27.9	10	2	3.0
7	1	2.5	10	9	7.6
7	3	2.5	10	11	14.0
7	4	14.0	10	13	1.3
7	5	29.2	10	16	3.8
7	6	11.4	10	18	59.7
7	7	6.4	11	3	3.8
7	14	12.7	11	7	3.8
7	17	22.9	11	9	45.7
7	19	1.3			
7	20	10.2			
7	21	34.3			
7	24	35.6			
7	25	2.5			

APPENDIX B
LEAF AREA INDEX DATA

Table B-1. Leaf area index data collected on Florunner in 1988 at AREC, Marianna, Florida.

TMT[*]	REP	Days After Planting							
		61	71	83	92	103	113	127	137
		7/5	7/15	7/27	8/5	8/16	8/26	9/9	9/19
GS	1	0.41	1.27	1.53	1.57	2.46	3.77	2.68	3.39
	2	0.63	1.08	1.23	2.36	2.54	3.65	3.42	3.59
	3	0.50	1.55	2.30	1.56	3.50	4.64	4.56	6.04
	4	0.40	1.53	1.23	1.87	3.17	3.27	3.96	4.01
	Ave.	0.48	1.36	1.57	1.84	2.91	3.83	3.65	4.25
Control	1	0.50	1.51	1.55	2.03	2.02	1.83	0.38	0.59
	2	0.76	1.15	1.08	1.36	1.20	1.74	0.74	0.81
	3	0.67	1.42	1.61	2.60	1.58	1.20	0.74	0.87
	4	0.74	1.79	1.74	1.49	2.11	1.09	0.34	0.57
	Ave.	0.67	1.47	1.49	1.87	1.73	1.46	0.55	0.71
0.13(X)	1	0.66	1.29	2.09	2.49	2.40	2.38	0.56	0.67
	2	0.64	2.04	2.07	1.61	1.89	1.60	0.89	0.73
	3	0.69	1.40	2.41	1.87	2.48	2.04	0.58	0.84
	4	0.77	1.05	2.23	2.48	1.87	2.21	0.49	1.54
	Ave.	0.69	1.44	2.20	2.11	2.16	2.06	0.63	0.94
0.25(X)	1	0.63	1.48	1.63	2.03	3.39	1.92	0.38	0.51
	2	0.63	0.91	2.67	2.49	3.14	1.99	0.97	1.31
	3	0.84	1.44	2.00	1.84	1.96	1.84	1.30	1.67
	4	0.57	1.53	1.59	1.66	3.55	4.06	0.98	1.40
	Ave.	0.67	1.34	1.97	2.01	3.01	2.45	0.91	1.22

[*] Fungicide treatments (an unsprayed control, four spray rates initiated at 1% incidence where X = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP).

Table B-1 -- Continued.

TMT*	REP	Days After Planting							
		61	71	83	92	103	113	127	137
		7/5	7/15	7/27	8/5	8/16	8/26	9/9	9/19
0.50(X)	1	1.04	2.03	1.48	2.26	2.00	2.46	0.52	0.72
	2	0.83	1.95	2.03	1.87	2.72	2.25	0.99	0.55
	3	0.73	0.91	1.05	1.62	2.32	2.57	1.28	1.41
	4	0.58	1.08	1.66	1.04	2.26	2.42	0.85	1.00
	Ave.	0.79	1.49	1.56	1.69	2.32	2.42	0.91	0.92
1.00(X)	1	0.41	1.13	1.51	1.32	2.47	3.39	2.54	2.73
	2	0.54	1.42	1.98	1.88	2.20	2.77	2.10	2.57
	3	0.54	0.89	1.27	1.82	2.84	2.81	2.09	2.12
	4	0.73	1.13	1.05	2.11	2.65	1.42	1.70	2.27
	Ave.	0.55	1.14	1.45	1.78	2.54	2.59	2.11	2.42

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*Fungicide treatments (an unsprayed control, four spray rates initiated at 1% incidence where X = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP).

Table B-2. Mean Leaf area index for Florunner and Southern Runner in 1989 at AREC, Marianna, Florida.

TMT*	Days After Planting							
	67 7/21	77 7/31	88 8/11	103 8/26	110 9/2	117 9/9	124 9/16	131 9/23
Florunner								
Control	2.31	2.94	3.61	1.82	0.83	0.31	0.14	0.10
0.25 (X)	2.25	3.12	3.64	2.91	1.10	0.72	0.21	0.25
0.50 (X)	2.15	3.41	3.75	3.13	1.22	0.84	0.51	0.47
0.75 (X)	1.93	3.34	3.81	3.12	1.67	1.15	0.74	0.61
GS	2.16	3.35	3.92	4.43	4.93	4.51	4.35	4.41
Southern Runner								
Control	2.54	3.23	3.71	2.50	1.01	0.89	0.52	0.24
0.25 (X)	2.86	3.14	4.53	3.21	1.24	1.07	0.75	0.84
0.50 (X)	3.13	3.45	4.47	3.42	2.14	1.27	0.91	0.74
0.75 (X)	2.12	3.84	4.51	4.23	3.86	2.56	1.45	1.34
GS	2.26	3.57	4.93	6.15	5.94	5.42	4.87	4.92

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*Fungicide treatments (an unsprayed control, three spray rates initiated at 0.5% incidence where X = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP).

APPENDIX C
CANOPY REFLECTANCE DATA

Table C-1. Percent reflectance at 800 nm for Florunner in 1988 at AREC, Marianna, Florida.

TMT*	REP	Days After Planting							
		74	85	97	106	114	121	130	137
		7/18	7/29	8/10	8/19	8/27	9/3	9/12	9/19
Control	1	50.1	56.4	42.8	49.6	48.8	37.9	32.8	35.7
	2	43.6	54.4	38.8	46.4	46.5	38.3	30.2	27.3
	3	46.0	57.9	45.7	47.1	46.0	34.1	28.2	25.8
	4	44.6	50.1	45.9	46.8	51.7	41.9	34.8	34.9
	Ave.	46.1	54.7	43.2	47.5	48.2	38.1	31.5	30.9
0.13 (X)	1	48.9	56.1	40.9	45.9	46.6	35.5	28.8	34.4
	2	53.2	60.8	44.3	48.9	46.7	31.9	25.7	28.6
	3	48.2	58.3	43.7	47.1	49.9	35.5	27.9	31.9
	4	49.1	56.7	49.6	50.4	56.8	43.4	35.3	30.2
	Ave.	49.8	57.9	44.6	48.1	50.0	36.6	29.4	31.2
0.25 (X)	1	46.3	52.5	41.6	46.5	49.1	38.8	31.8	38.1
	2	47.2	61.5	50.3	54.5	56.5	44.6	35.1	34.3
	3	47.6	58.9	50.7	56.0	62.2	52.4	34.9	32.5
	4	45.3	55.2	48.0	54.6	60.6	48.3	38.1	39.4
	Ave.	46.6	57.0	47.6	52.9	57.1	46.0	34.9	36.1
0.50 (X)	1	46.2	55.9	45.1	54.1	54.1	44.6	37.3	42.5
	2	49.9	61.3	46.1	48.8	50.6	41.4	32.5	30.4
	3	44.3	53.4	38.9	48.4	55.7	48.4	36.9	42.0
	4	44.3	52.3	42.7	48.7	56.0	49.1	40.2	43.9
	Ave.	46.2	55.7	43.2	50.0	54.1	45.8	36.7	39.7

*Fungicide treatments (an unsprayed control, four spray rates initiated at 1% incidence where X = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP).

Table C-1 -- Continued.

TMT*	REP	Days After Planting							
		74 7/18	85 7/29	97 8/10	106 8/19	114 8/27	121 9/3	130 9/12	137 9/19
1.00 (X)	1	44.0	46.2	41.3	52.8	61.0	56.8	60.1	65.3
	2	48.6	56.9	42.9	52.7	58.1	53.2	46.5	52.0
	3	45.3	53.4	45.8	54.4	56.9	50.3	45.1	46.3
	4	51.2	53.1	46.8	49.0	59.6	51.9	36.5	37.4
	Ave.	47.3	52.4	44.2	52.2	58.9	53.1	47.1	50.1
GS	1	45.4	47.6	44.3	56.0	63.9	61.3	61.8	61.8
	2	40.6	55.3	45.5	56.6	65.1	66.7	58.9	64.9
	3	46.4	53.8	48.4	59.1	68.6	70.4	68.5	69.8
	4	44.4	52.0	45.5	56.8	68.2	64.2	56.7	59.0
	Ave.	44.2	52.2	45.9	57.1	66.4	65.6	61.5	63.9

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*Fungicide treatments (an unsprayed control, four spray rates initiated at 1% incidence where X = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP).

Table C-2. Percent reflectance at 800 nm for Florunner in 1989 at AREC, Marianna, Florida.

TMT*	REP	Days After Planting							
		80	99	109	115	119	125	129	136
		8/3	8/22	9/1	9/7	9/11	9/17	9/21	9/28
CONTROL	1	63.1	59.4	41.9	40.0	36.1	24.6	27.6	20.3
	2	69.5	57.3	38.1	33.4	33.8	25.0	24.9	20.9
	3	63.4	64.2	55.2	45.6	46.5	34.2	32.5	29.9
	4	70.9	54.2	41.0	35.4	34.5	27.1	29.5	25.7
	Ave.	66.7	58.8	44.0	38.6	37.7	27.7	28.6	24.2
0.25 (X)	1	69.2	56.4	32.2	26.9	26.3	23.0	22.5	21.5
	2	75.9	61.5	38.5	36.5	34.3	25.2	30.0	22.6
	3	78.8	59.4	36.1	33.6	34.3	25.3	26.9	22.0
	4	86.0	51.4	34.5	35.0	33.0	26.5	27.5	23.5
		77.5	57.2	35.3	33.0	32.0	25.0	26.7	22.4
0.50 (X)	1	65.9	59.7	31.6	29.1	27.7	24.8	23.0	24.7
	2	72.0	59.4	34.3	31.5	31.6	26.0	25.3	23.6
	3	74.7	60.6	33.8	33.7	33.3	26.3	27.7	23.6
	4	71.2	54.0	33.1	34.2	33.1	26.9	29.7	26.3
		71.0	58.4	33.2	32.1	31.4	26.0	26.4	24.6
0.75 (X)	1	66.4	61.9	37.5	33.6	31.8	24.9	25.9	21.8
	2	68.6	62.9	41.9	33.0	34.3	29.2	26.1	25.9
	3	68.9	63.8	41.0	36.9	34.7	27.9	27.2	24.5
	4	74.1	59.9	43.5	39.1	36.8	29.6	32.4	30.7
		69.5	62.1	41.0	35.7	34.4	27.9	27.9	25.7
GS	1	70.8	72.6	69.9	67.5	66.8	79.7	64.3	59.5
	2	73.9	75.9	71.8	69.0	65.4	57.3	61.7	59.0
	3	68.1	74.3	68.9	68.9	72.0	59.2	68.4	59.2
	4	66.7	63.3	72.6	72.4	71.6	58.8	68.6	63.2
		69.9	71.5	70.8	69.5	69.0	63.8	65.8	60.2

*Fungicide treatments (an unsprayed control, three spray rates initiated at 0.5% incidence where X = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP).

Table C-3. Percent reflectance at 800 nm for Southern Runner in 1989 at AREC, Marianna, Florida.

TMT*	REP	Days After Planting							
		80	99	109	115	119	125	129	136
		8/3	8/22	9/1	9/7	9/11	9/17	9/21	9/28
Control	1	70.4	71.3	61.2	61.2	51.9	44.2	46.9	42.5
	2	73.1	71.7	61.0	52.8	50.7	42.6	44.8	43.0
	3	82.8	69.7	65.6	61.9	61.9	46.8	55.8	50.0
	4	71.0	63.7	63.8	58.9	57.0	41.8	50.2	44.4
		74.3	69.1	62.9	58.7	55.4	43.9	49.4	45.0
0.25 (X)	1	72.1	72.8	61.2	55.7	54.8	44.0	48.4	44.8
	2	73.9	72.5	64.5	59.4	54.0	44.3	48.1	44.0
	3	85.3	71.9	65.2	60.5	61.7	47.6	54.6	47.2
	4	68.9	65.6	65.8	59.5	62.3	48.5	57.2	49.1
		75.1	70.7	64.2	58.8	58.2	46.1	52.1	46.3
0.50 (X)	1	70.3	69.1	58.6	57.2	49.9	43.1	45.5	41.9
	2	71.6	75.4	62.3	54.2	55.8	48.8	48.7	47.3
	3	69.8	70.2	66.4	60.1	60.0	47.4	54.5	46.6
	4	77.2	66.9	64.6	57.2	61.4	48.7	52.2	49.4
		72.2	70.4	63.0	57.2	56.8	47.0	50.2	46.3
0.75 (X)	1	70.9	73.4	66.7	62.4	57.3	50.6	55.3	52.4
	2	72.5	74.3	65.6	56.9	56.7	50.1	51.2	52.3
	3	82.8	72.2	66.4	65.1	65.2	50.8	59.7	51.4
	4	77.7	72.0	69.1	63.3	59.1	50.6	59.7	53.1
		76.0	73.0	67.0	61.9	59.6	50.5	56.5	52.3
GS	1	72.9	78.7	76.0	71.1	73.6	64.2	67.9	65.1
	2	75.7	79.9	73.0	74.3	71.9	65.5	69.7	63.0
	3	79.2	73.9	74.6	73.4	79.6	65.5	77.6	67.5
	4	83.7	72.3	75.8	70.5	77.5	67.6	74.3	68.0
		77.9	76.2	74.9	72.3	75.7	65.7	72.4	65.9

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*Fungicide treatments (an unsprayed control, three spray rates initiated at 0.5% incidence where x = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP).

APPENDIX D
TOTAL DISEASE SEVERITY DATA

Table D-1. Total disease severity (%) data for Florunner in 1988 at AREC, Marianna, Florida.

Mo.	Day	DAP	TREATMENT*					
			CTL	0.13(X)	0.25(X)	0.50(X)	1.00(X)	GS
6	28	54	0.00	0.00	0.00	0.00	0.00	0.00
7	5	61	0.09	0.11	0.26	0.28	0.21	0.00
7	15	71	0.25	0.32	0.39	0.41	0.35	0.05
7	27	83	0.56	0.71	1.45	1.59	2.81	0.56
8	5	92	3.68	5.23	4.99	5.58	4.32	1.96
8	16	103	32.56	28.95	25.68	12.52	7.64	2.89
8	26	113	55.68	41.58	29.87	21.76	12.35	5.52
9	9	127	68.64	48.93	35.67	26.77	16.32	6.30
9	19	137	96.55	55.36	43.86	38.51	31.25	10.01

*Fungicide treatments (an unsprayed control, four spray rates initiated at 1% incidence where x = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP).

Table D-2. Total disease severity (%) data for Florunner and Southern Runner in 1989 at AREC, Marianna, Florida.

Mo.	Day	DAP	CTL	TREATMENT* 0.25(X)	0.50(X)	1.00(X)	GS
				Florunner			
7	6	52	0.05	0.02	0.00	0.00	0.00
7	21	67	0.13	0.21	0.16	0.10	0.01
7	31	77	1.59	0.98	0.21	0.25	0.09
8	11	88	7.68	6.95	7.84	7.96	4.21
8	26	103	26.45	18.92	15.42	18.41	6.55
9	2	110	69.71	72.31	65.89	66.73	10.11
9	9	117	75.63	74.52	79.54	75.36	11.27
9	16	124	86.77	87.39	85.24	77.51	22.29
9	23	131	98.94	97.61	96.36	92.31	29.56
				Southern Runner			
7	6	52	0.00	0.00	0.00	0.00	0.00
7	21	67	0.02	0.05	0.00	0.05	0.00
7	31	77	0.10	0.09	0.05	0.08	0.00
8	11	88	5.32	5.25	3.68	2.20	1.96
8	26	103	14.67	10.15	9.66	8.57	6.39
9	2	110	49.65	39.48	27.98	25.23	16.53
9	9	117	56.77	57.14	56.55	51.11	14.56
9	16	124	68.79	69.33	59.18	52.91	27.62
9	23	131	64.25	69.57	62.23	61.53	29.09

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*Fungicide treatments (an unsprayed control, three spray rates initiated at 0.5% incidence where x = 1.75 L/ha, and GS or growers schedule initiated at 35 DAP).

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BIOGRAPHICAL SKETCH

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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